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14. ABSTRACT

Purpose: Use the meta-analytic approach to examine the effects of exercise on bone mineral density (BMD) using individual patient data (IPD) and to compare these results with summary data from the same studies. Scope: The specific aim for this project period was to analyze IPD from existing training studies dealing with the effects of exercise on BMD at the femoral neck in postmenopausal women. Major finding: The major finding for this reporting period was that exercise did not improve BMD at the femoral neck in postmenopausal women.

15. SUBJECT TERMS
exercise, bone, meta-analysis, osteoporosis, bone density, physical activity, physical fitness, men, women

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I. INTRODUCTION

Bone health is critical for optimal performance and the prevention of fractures associated with low bone mineral density (BMD). Our first two-year period of funding focused on using the meta-analytic approach to examine the effects of exercise on BMD in adult humans using summary means from completed studies. Since no meta-analysis had existed using individual patient data (IPD) to examine the effects of exercise on BMD, our second period of funding was devoted to examining the feasibility of such. The specific aims of the second project period were to (1) compare summary versus IPD in relation to the overall magnitude of effect that exercise has on BMD, (2) compare summary versus IPD in relation to the effect of potentially confounding variables (age, training program, etc.) on changes in BMD, and (3) provide recommendations for future research regarding the use of summary versus IPD for examining the effects of exercise on BMD. The results of this project will help identify the best approach to use (summary versus IPD) when attempting to arrive at a more objective conclusion regarding the effects of exercise on BMD in humans. In addition, this will be the first meta-analysis using IPD in the area of exercise and BMD. Finally, the results of this project will provide the Armed Forces with a better understanding of the effects of exercise on BMD and will also help to identify what programs, if any, will provide for optimal bone development and maintenance.

II. BODY

A. Statement of Work

For this reporting year, we have accomplished the following tasks as outlined in our statement of work: (1) analyzed data, and (2) published one abstract that was presented at a national conference (See Appendix A).

The purpose of this study was to conduct a meta-analysis using IPD in order to examine the efficacy of exercise for improving bone mineral density BMD at the femoral neck in postmenopausal women. Individual patient data were available for ten controlled clinical trials (43% of eligible studies) that included 595 subjects ages 42 to 92 years. Across all designs and categories, there was an increase in BMD of 0.73 +/- 5.52% and 0.45 +/- 6.78% respectively, in the exercise and control subjects. However, comparison of initial and final BMD values between exercise and control subjects revealed no statistically significant effect of exercise on femoral neck BMD. In addition, random-effects analyses revealed no statistically significant within or between-group differences for studies in which IPD were available versus those that were not. The results of this study suggest that exercise is not efficacious for improving and/or maintaining femoral neck BMD in postmenopausal women. However, a need exists for additional research in this area before clinical recommendations can be made regarding the effectiveness of exercise for improving and/or maintaining femoral neck BMD in postmenopausal women.

III. KEY RESEARCH ACCOMPLISHMENTS FOR REPORTING PERIOD

A. We found that exercise did not help to maintain or increase BMD at the femoral neck in postmenopausal women. In addition, we found no differences in femoral neck BMD when studies in which IPD were available were compared to those studies in which IPD were not available.

IV. REPORTABLE OUTCOMES FOR REPORTING PERIOD

A. Manuscripts & Presentations (Refereed)

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1. **Kelley, G.A.,** Kelley, K.S. (2005). Exercise and bone mineral density at the femoral neck in postmenopausal women: A meta-analysis of controlled clinical trials using individual patient data. American Public Health Association (See Appendix A) Can be also be accessed at: http://apha.confex.com/apha/133am/techprogram/paper_110770.htm

   Note: During our current no-cost extension year we are seeking publication for this work in the American Journal of Obstetrics and Gynecology.

V. CONCLUSIONS FOR REPORTING PERIOD

A. Importance of Completed Research

The most important finding for this reporting period was that exercise (collectively) did not improve femoral neck BMD in postmenopausal women. This is consistent with the majority of findings from the original studies included in our IPD meta-analysis in that 79% of the outcomes at the femoral neck were reported as being nonsignificant. Our findings appear to be somewhat different than the recent position statement from the National Institutes of Health Consensus Development Panel on Osteoporosis, Prevention, Diagnosis, and Therapy, which suggested that exercise during the later years probably has a modest effect on slowing the decline in BMD.[5] However, this was a broad statement and not specific to any one site in the body. Our findings also conflict with our previous meta-analytic work in which an approximate 2% improvement in BMD was found at the hip as a result of site-specific aerobic exercise and progressive resistance training.[3;4] One of the possible reasons for the discrepant results between our current and previous meta-analytic work may have to do with the fact that the summary measures obtained in our previous research were the result of pooling the outcomes from all sites assessed at the femur (femoral neck, Ward's triangle, trochanter, intertrochanter). Consequently, it may be that improvements in BMD occur at one or more sites other than the femoral neck (Ward's triangle, trochanter, intertrochanter). However, we were unable to address the effects of exercise at other femur sites at the because of a lack of reported data.

The recent consensus statement from the National Institutes of Health Consensus Development Panel on Osteoporosis, Prevention, Diagnosis, and Therapy suggested that higher impact activities and resistance training may have the greatest effect on BMD.[5] Unfortunately, the majority of studies included in this investigation used lower

versus higher impact types of activities, primarily walking, as an intervention. In addition, while exercises designed to strengthen the hip were used in studies that employed a progressive resistance training protocol, the majority of exercises focused on movements designed to strengthen the upper body. Thus, it may be that the lack of improvement in femoral neck BMD in this investigation was the result of the exercise protocols employed. However, while higher impact activities such as jumping and high impact aerobic dance may be more beneficial to femoral neck BMD in postmenopausal women,[7] this has to be countered with issues of adherence to a regular program of exercise as well as the potential to place the subject at an increased risk for injury, particularly stress factures and osteoarthritis.[6] Thus, from a practical standpoint, the lower impact types of exercise protocols that were employed in many of our included studies are probably the most appropriate. This may be especially true for walking since it is the most common type of exercise in which people in the United States participate.[2]

Since the terms lower and higher impact are broad and fairly subjective terms, it would appear plausible to suggest that future studies examining the effects of exercise on BMD make some attempt to quantify the forces involved for the interventions employed. For those studies that employ a progressive resistance training protocol, additional lower leg exercises that may affect femoral neck BMD should be employed. Incorporation of the above suggestions should result in a better understanding regarding the efficacy of exercise for improving BMD at the femoral neck.

B. Suggestions for Future Work

Future research dealing with the effects of exercise on BMD in postmenopasual women should quantify the site-specific forces of the various exercise interventions employed. In addition, a need exists for additional research on the effects of exercise at hip sites other than just the femoral neck, i.e., Ward's triangle, trochanter, intertrochanter. Furthermore, since most progressive resistance training studies relied predominantly on upper versus lower body exercises in their protocols, it would appear plausible to suggest that future studies that use progressive resistance training as an intervention include additional lower leg exercises when examining changes in BMD at the femur. Finally, while it is important for future research to examine the efficacy and effectiveness of various exercise interventions on femoral neck BMD, it would appear reasonable to suggest that a need exists for increased research that addresses the effects of exercise for preventing osteoporotic fractures in the presence and/or absence of changes in BMD.

From a meta-analytic perspective, IPD has the potential for increased statistical power as well as a more thorough examination of potential covariates. However, this has to be countered with the amount of IPD retrieved as well as the increased time and effort to retrieve such. Since we had difficulty in obtaining IPD from all eligible studies and no differences were observed in femoral neck BMD when we compared studies in which IPD were available versus those that were not, we recommend that future meta-

analytic work dealing with the effects of exercise on BMD at the femur in postmenopausal women rely on summary means versus IPD.

C. So What?

Despite the fact that exercise did not have any effect on femoral neck BMD in postmenopausal women, such activities should almost always be recommended. For example, while exercise may not improve femoral neck BMD, it may increase muscular strength and balance and improve postural stability, thus reducing the risk of falling and subsequent fractures that can result from falling.[1;5]

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VII. APPENDICES

A. Exercise and Bone Mineral Density Abstract

APPENDIX A

American Public Health Association
133rd Annual Meeting & Exposition
December 10-14, 2005
Philadelphia, PA

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Exercise and bone mineral density at the femoral neck in postmenopausal women: A meta-analysis of controlled clinical trials using individual patient data

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The purpose of this study was to conduct a meta-analysis using individual patient data (IPD) in order to examine the efficacy of exercise for improving bone mineral density (BMD) at the femoral neck in postmenopausal women. Ten controlled clinical trials that included 595 subjects ages 42 to 92 years met our criteria for inclusion. Across all designs and categories, there was an increase in BMD of 0.73 +/- 5.52% and 0.45 +/- 6.78% respectively, in the exercise and control subjects. However, comparison of initial and final BMD values between exercise and control subjects revealed no statistically significant effect of exercise on femoral neck BMD. In addition, random-effects analyses revealed no statistically significant within or between-group differences for studies in which IPD were available versus those that were not. In conclusion, the results of this study suggest that exercise is not efficacious for improving and/or maintaining femoral neck BMD in postmenopausal women. However, a need exists for additional research in this area before clinical recommendations can be made regarding the effectiveness of exercise for improving and/or maintaining femoral neck BMD in postmenopausal women.

Learning Objectives: At the end of this session, the participant will be able to

- Describe the current state of knowledge regarding the effects of exercise on bone mineral density at the femoral neck in postmenopausal women.
- Describe the effects of potentially confounding variables on changes in bone mineral density at the femoral neck in postmenopausal women as a result of exercise.
- Describe weaknesses in the literature and identify areas for future research dealing with the effects of exercise on bone mineral density at the femoral neck in postmenopausal women.

Keywords: Exercise, Aging

Presenting author's disclosure statement:

I wish to disclose that I have **NO** financial interests or other relationship with the manufactures of commercial products, suppliers of commercial services or commercial supporters.

Research Issues among Older Adults

The 133rd Annual Meeting & Exposition (December 10-14, 2005) of APHA